Hurricane Evacuation Time Estimates for the Texas Gulf Coast

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EXECUTIVE SUMMARY

This report describes the application of an improved method for developing hurricane evacuation time estimates (ETEs). In contrast to the procedure used in previous analyses, Lindell, Prater and Wu (2001) proposed an *Empirically Based Large-scale Evacuation time estimate Method (EMBLEM)* that uses two empirical evacuation time components for the evacuating population—warning time and preparation time. This differs from the previous procedure of adding an arbitrary three-hour time buffer to account for these activities. The empirically based estimates demonstrate that ETEs can be very long when warnings are slow or when evacuees must return home before evacuating. In addition, the EMBLEM procedure accounts for the effects of spontaneous evacuation. This can substantially increase the ETEs for hurricanes in Categories One and Two when inland risk areas are densely populated and their populations are prone to evacuate. Finally, the EMBLEM procedure accounts for the time required for evacuees to travel out of the risk area. For counties whose population centers are located well inland from the coast, addition of this component makes little difference. When a major hurricane is forecast to strike a county that has a significant number of people living on the coast or on barrier islands, the inclusion of response time can add as much as two hours to the ETEs.

The EMBLEM procedure does not account for the evacuation of transit-dependent populations and special facilities. As is the case for other methods of evacuation analysis, ETEs for these population segments must be computed separately. Finally, there is uncertainty about the estimates for many of the input variables, so further analyses should be conducted to determine the extent to which any ETEs will be significantly affected by changes in the values of these parameters. In particular. these analyses should examine the effects of variation in the distributions of warning times and preparation times, the number of evacuating vehicles per household, the rate of warning compliance and spontaneous evacuation, and evacuee route choice as well as the effects of capacity changes such as lane reversals.

Recent hurricane evacuation times for the Texas Gulf coast have been estimated using a procedure, proposed by Safwat and Youssef (1997), in which the Texas Gulf coast is divided into five separate study areas that are based upon the National Hurricane Center's designated basins for the SLOSH model. To estimate evacuation times for each category of hurricane within each study area, evacuation route systems (ERSs) are defined for each study area. Each ERS is a relatively independent system of roads that residents will use to travel from the risk area to inland counties. Each ERS generally corresponds to the road network for a single county, but some ERSs serve only part of a county and others serve multiple counties. An ERS generally consists of a primary evacuation route (PER) together with the collectors, arterials, and minor highways that feed it. The estimated number of households expected to use an ERS is determined from census data on the population of the geographic area it serves.

According to Safwat and Youssef's procedure, trip generation time (TGT)—the time required for households to begin evacuating—is assumed to take three hours after local authorities make an evacuation decision. This time lag, which is designed to account for warning dissemination and household preparation to evacuate, implicitly assumes a step function in which no vehicles enter the evacuation route system for three hours, after which time the system immediately reaches capacity. The number of vehicles evacuating in response to a given hurricane category is computed by multiplying the number of households in the corresponding risk areas (e.g., Risk Areas 1 and 2 for a Category Two hurricane) by the average number of evacuating vehicles per household. Evacuating vehicles are assumed to attempt entry to the ERS, which operates at maximum capacity until all evacuating vehicles have entered. Safwat and Youssef compute response time by dividing the total number of evacuating vehicles by the total traffic capacity of the ERS and rounding up to the nearest whole hour. According to their procedure, clearance time for the entire ERS for a given category of storm is estimated by adding the estimate of response time to the three hours required for warning and preparation time.

Lindell, Prater and Wu (2002) recently developed an *Empirically Based Large-scale Evacuation time estimate Method* (EMBLEM) that integrates Safwat and Youssef's procedure with earlier work by Urbanik, Desrosiers, Lindell and Schuller (1980). The Urbanik, et al. (1980) model defines evacuation times in terms of four components: a) the time required by authorities to make an evacuation decision, b) the time required for a household to receive a warning, c) the time that a household devotes to preparation for evacuation, and d) the response time required to travel to safety. The EMBLEM procedure extends the Urbanik, et al. model by dividing response time into three components: 1) travel from home to the nearest access point on the PER, 2) waiting in line for access to the PER (i.e., queuing), and 3) travel on the PER from the access point to the inland boundary of the risk area.

The ETEs computed using EMBLEM differ from those of Sawfat and Youssef in nine ways. First, the EMBLEM analyses calculate the total number of households in each risk area from 2000 census data. By contrast, Safwat and Youssef used population projections from the 1990 census that were adjusted for the estimated rate of population growth in each of the coastal counties. Actual census data are, obviously, more accurate than projectoins but the differences do not materially affect the ETEs.

Second, EMBLEM calculates the number of evacuating households by adjusting the total number of households in each risk area for non-compliance in the warned risk areas and spontaneous evacuation from inland risk areas that have not been advised to evacuate. Although Safwat and Youssef's description of their procedure acknowledges the need to adjust for noncompliance and spontaneous evacuation, the data in their ETE tables do not appear to have accounted for spontaneous evacuation.

Third, the number of evacuating vehicles in each risk area is computed by multiplying the estimated number of evacuating households by the estimated number of evacuating vehicles per household. Although the computational procedure is the same in both methods, EMBLEM uses a larger number of evacuating vehicles per household. Specifically, the Safwat and Youssef analyses used values specific to each county that ranged from 1.35 in the Coastal Bend Study Area to 1.50 in the Valley Study Area. By contrast, the current analyses use a common value of 1.62. As Lindell, Prater, Sanderson, Lee, Zhang, Mohite & Hwang (2001) noted, this value is larger than any reported in previous evacuations (Dow & Cutter, 2002; Post, Buckley, Shuh & Jernigan, 1999; Prater, Wenger & Grady, 2000) or evacuation expectations surveys (Ruch & Schumann, 1997, 1998) but is used because it is a plausible conservative estimate.

Fourth, EMBLEM uses a TGT distribution function that is based upon empirical data indicating that the 100th percentile of the TGT distribution (the time at which all evacuating households would be on the road) would not be reached until 10.5 hours (Lindell, et al., 2001). However, the use of a TGT with an upper limit this large could produce very misleading ETEs in areas having extremely small populations and ample traffic capacity because the ETEs in such areas are determined by TGT, not by evacuation route capacity. Conversely, a large upper limit for the TGT distribution produces no differences in ERSs with large population and limited capacity. This is because it is immaterial whether the last households to evacuate are delayed by slow evacuation preparations or by waiting in queues. Consequently, the TGT distribution used in EMBLEM was cut off at 98th percentile rather than 100th percentile, so the maximum TGT is 6.5 hours—which, nonetheless, is more than twice as long as Safwat and Youssef's arbitrary three-hour time delay.

Fifth, data from Drabek (1996) suggest that tourists and other transients will evacuate immediately, regardless of the risk area in which they are staying. In addition, the EMBLEM procedure assumes transients have shorter TGTs than residents.

Sixth, EMBLEM considers the time required to travel from an evacuating household's home to the nearest access point to the PER. In practice, this distance is usually no more than five miles and is only as much as ten miles in the least densely populated ERSs on the Texas coast. Consequently, the corresponding evacuation time component is expected to be no more than 20 minutes.

Seventh, the EMBLEM procedure calculates the number of vehicles successfully entering each PER by using a series of equations in which the number of vehicles attempting to enter a PER during each 15-minute time interval is the sum of the number of vehicles arriving at the PER plus the number of vehicles in the queue that were unable to enter it during the previous time period. The number of vehicles that enter the PER during each time period is equal to the capacity of the PER and the excess demand remains in the queue. This calculation is repeated until all of the vehicles have entered a PER and the time is noted at which the last vehicle gains access to it. Previous ETEs were based on the assumption that ERS access time could be calculated by dividing the total number of vehicles attempting to evacuate by PER capacity.

Eighth, EMBLEM calculates response time by adding the estimate of access time for the last vehicle in the queue to the time required for a vehicle to travel at 30 mph from the farthest populated location on the coast to the inland boundary of the appropriate risk area (e.g., Risk Area 4 for a Category Four hurricane). This travel time component was not included in previous analyses and can add as much as an hour to the ETEs in some ERSs.

Finally, the ETEs from EMBLEM are based upon Safwat and Youssef's estimates of highway traffic capacity, but have been updated on the basis of Regional Liaison Officers' reports of highway construction and repair. In a few cases, examination of previous analyses showed that common links among the evacuation routes had been overlooked so downward adjustments were made to the estimated traffic capacity of those ERSs.

RESULTS

This section presents the results of the ETE analyses using EMBLEM and compares them to the ETEs computed by Safway and Youssef. The discussion section that follows examines the differences between the two sets of ETEs and describes the limitations that still remain in the EMBLEM ETEs. Appendixes A-E present information that is specific to each of the five study areas.

Before presenting the results, it is important to recall that Safwat and Youssef's (1997) tables reported only the response times in their ETE analyses; the three-hour TGT was added later in the ESTED computer program (Hazard Analysis Laboratory, 1999). To make the two sets of ETEs comparable, three hours have been added to Safwat and Youssef's ETEs and the resulting values (i.e., five hours) are reported in Table 1. The Safwat and Youssef ETE is the first entry in each cell and the EMBLEM ETE is the second entry.

The first significant difference that can be seen in Table 1 is that the minimum ETE from EMBLEM is seven hours. As noted above, three hours have been added to all of Safwat and Youssef's ETEs, which increases their two-hour minimum ETE to five hours. The remaining two-hour difference between Safwat and Youssef's five-hour minimum ETE and EMBLEM's seven-hour minimum ETE arises from the fact that the current analyses rely on TGTs derived from empirical warning and preparation times. The EMBLEM TGT is 6.5 hours and the addition of travel time on the PER adds another half hour.

Table 1 shows that there are only slight differences between Safwat and Youssef's estimates and EMBLEM estimates of ETEs in lightly populated areas with adequate ERS capacity. In such locations (e.g., Willacy, Refugio/Aransas, Victoria, and Hardin counties), risk area clearance times will be determined by the time required for households to be warned and to prepare to evacuate, not the time required for them to travel to the principal evacuation routes or from there to the inland boundary of the area at risk. It is unlikely that there will be long response times due to traffic queues within the risk area.

TABLE 1: Comparison of ETEs Calculated Using the Safwat and Youssef Model With Those Computed Using EMBLEM

VALLEY STUDY AREA

	CAT1	CAT2	CAT3	CAT4	CAT5
VSA1: Cameron South	7	8	9	10	11
VSA2: Cameron North *	9/15	9/21	13/28	18/32	27/33
VSA3: Willacy	5/7	5/7	5/7	5/8	7/8

* Fall ETEs for VSA2 can be reduced by 3 hours because tourist occupancy is assumed to be reduced from 100% to 50%.

COASTAL BEND STUDY AREA

	CAT1	CAT2	CAT3	CAT4	CAT5
CSA1: Kenedy/Kleberg	5/7	5/7	7/8	7/9	12/9
CSA2: Nueces*	5/14	7/20	28/28	31/31	32/32
CSA3: Refugio/Aransas	7/8	10/8	12/8	13/8	13/8
CSA4: San Patricio	5/8	8/11	16/15	19/17	20/18

* Fall ETEs for CSA2 can be reduced by 1 hour because tourist occupancy is assumed to be reduced from 100% to 50%.

MATAGORDA STUDY AREA

	CAT1	CAT2	CAT3	CAT4	CAT5
MSA1: Calhoun/Victoria	5/8	7/8	10/9	10/10	11/10
MSA2: Calhoun/Jackson	5/7	5/8	5/8	5/8	5/8
MSA3: Matagorda West	6/7	6/8	7/8	8/9	8/9
MSA4: Matagorda East	5/7	5/8	5/8	6/8	6/8
MSA5: Victoria	--	5/7	5/7	5/7	5/7

HOUSTON/GALVESTON STUDY AREA

	CAT1	CAT2	CAT3	CAT4	CAT5
GSA1: Brazoria	5/7	5/9	13/13	16/15	17/15
GSA2: Galveston West/Harris South	8/14	13/20	25/28	29/32	32/33
GSA3: Harris Central	5/7	5/7	7/9	8/10	10/10
GSA4: Harris East	5/8	5/12	10/17	12/19	17/20

LAKE SABINE STUDY AREA

	CAT1	CAT2	CAT3	CAT4	CAT5
SSA1: Chambers West	7	7	7	8	8
SSA2: Chambers East/Galveston East	11/10	11/13	15/17	16/19	17/19
SSA3: Hardin	5/7	5/7	5/7	6/7	6/7
SSA4: Jasper	5/7	5/7	5/7	6/7	6/7
SSA5: Jefferson/Orange West*	5/14	5/20	23/29	28/33	32/34
SSA6: Liberty	--	5/7	6/7	7/7	9/7
SSA7: Newton	--	--	5/7	5/9	5/9
SSA8: Orange East *	5/7	9/7	19/10	21/11	21/12

* Fall ETEs for SSA5 and SSA8 can be reduced by .5 hour because tourist occupancy is assumed to be reduced from 100% to 50%.

By contrast, there are important ETE differences in densely populated ERSs that are due to the effects of noncompliance, spontaneous evacuation and, to a lesser extent, the effects of response time for evacuees who must travel a long distance to reach safety. Consideration of spontaneous evacuation consistently yields higher ETEs for Category One and Two hurricanes, especially when there is a densely populated area immediately inland from the coast that can provide a major source of spontaneous evacuees (e.g., Cameron North, Nueces, and Galveston West/Harris South for Category One and Two hurricanes, Jefferson/Orange West in Category One–Four hurricanes, and Harris East in Category Two–Four hurricanes). However, there is little difference in most ETEs for Category Five hurricanes because evacuees will have cleared the danger area by the time that they clear Risk Area 5 and there usually are no major population concentrations beyond Risk Area 5 that could generate spontaneous evacuation to delay evacuation traffic.

A significant decrease from the previous ETEs can be seen in the Orange East ERS, where Safwat and Youssef described much larger ETEs than those reported here for Category Three-Five hurricanes. The explanation for the difference is a substantial increase in highway traffic capacity due to the recent construction of additional lanes on US 87 and US 62.

DISCUSSION

It is noteworthy that both Safwat and Youssef's and EMBLEM's analyses identified large differences in the ETEs for some adjacent counties. The ETEs for San Patricio are significantly lower than those for Nueces, and the ETEs for Orange East and Chambers East/Galveston East are significantly lower than those for Jefferson/Orange West. Emergency Management Coordinators should consider balancing the evacuation demand across counties by diverting evacuating vehicles from one jurisdiction to another. For example, some traffic from Corpus Christi might be directed across the US 181 causeway to San Patricio and some traffic from Port Arthur might be directed westbound on SH 73 and northbound on FM 1406 to FM 365 or directly westbound on FM 365. This could add 800 vehicles per hour (vph) of traffic capacity. Additional traffic could be diverted inland on SH 73 to SH 62 which also could add 800 vph.

Moreover, EMBLEM's ETEs for Category Five hurricanes are no larger than previous ETEs for these storms because there usually is no opportunity for spontaneous evacuation beyond the study area in the more severe hurricanes. The one exception to this rule is Harris County, where the area beyond the inland boundary of the study area has a large population. A significant level of spontaneous evacuation from this area (especially the GSA3 ERS) could generate traffic queues that extend backward into the areas at risk. A similar problem could occur in ERSs where evacuation routes converge just outside the inland boundary of the study area. Examples of this potential problem exist in Driscoll (CSA 2, Nueces County) and Sinton (CSA 3, San Patricio County) There also, bottlenecks could form inland from the study area that extend back into the risk areas. Thus, further analyses are needed to address this issue.

It is important to recognize that there are a number of assumptions and simplifications that are common to both ETE methods and need to be examined in future analyses. First, preparation times were calculated on the assumption that risk area residents would be at home but, of course, this will not always be the case. If risk area residents are at work, there will be a variable delay in the initiation of evacuation because individuals will differ in the distance they must travel from work to home. The necessity for household members at work to return home would be expected to cause delays in TGTs of the affected households and, thus, extend the upper limit of the TGT distribution. However, such delays would not occur if workers travel home before a warning is issued.

Second, these analyses presumed that preparation does not begin until after an official warning is received. This assumption probably overstates TGTs because anecdotal evidence suggests that some households begin preparations prior to receiving an official warning. It is especially likely that some tasks will be completed before receiving a warning if a hurricane has maintained a relatively constant track over an extended period of time—leading risk area residents to expect that it will strike them eventually. It is not possible to assess the degree of conservatism in this assumption because there are no systematic data to indicate what proportion of hurricane evacuees will initiate preparations earlier than assumed. It also is important to note that there might be systematic differences in TGTs between risk areas if residents of areas nearer to the coast have a greater sense of urgency than residents of risk areas farther inland. For example, if residents of Risk Area 1 prepare to evacuate more rapidly than those in Risk Area 5, this could lead to the formation of queues under conditions in which they would not otherwise be expected or earlier queues under conditions in which they are expected.

Third, these analyses ignored the possibility that workers returning home would delay the evacuations of others. This effect will be small for workers traveling inland to return home because they must travel with the evacuation flow and would be indistinguishable from early evacuees. Similarly, those who must travel toward the coast to return home will initially constitute a counter-flow (which will not adversely affect the evacuation) and will subsequently become late evacuees. A significant problem will arise if many of those returning home must travel parallel to the coast because cross-flow traffic could interrupt the flow of evacuation traffic moving inland, thereby reducing the effective capacity of the evacuation routes.

Fourth, neither method of analysis considers the effect of evacuees taking undesignated evacuation routes. According to the evacuation expectations survey, 9-35% of coastal residents, depending upon study area, expect to take unofficial evacuation routes (Lindell, et al., 2001). Ignoring this phenomenon produces ETEs that are biased upward (i.e., higher than evacuation times would be in an actual hurricane). However, this upward bias will tend to be offset by the remaining evacuees' over-reliance on a single evacuation route, which conflicts with the assumption of balanced loads on the evacuation routes. For example, Prater, et al. (2000) and Dow and Cutter (2002) found that evacuees in Hurricanes Bret and Floyd, respectively, overloaded the interstate highways and neglected other designated evacuation routes. Such excessive demand on a single evacuation route would cause actual evacuation times to exceed the ETEs, but this problem can be avoided if local law enforcement personnel are successful in balancing evacuation traffic across the principal highways in the ERS. Alternatively, EMBLEM ETEs could be recalculated under the assumption of imbalanced evacuation route choices because this method also can be used to analyze traffic demand that is balanced across evacuation routes.

Fifth, both the current and previous ETEs use a general 20% downward adjustment in traffic route capacity. This adjustment probably is adequate to account for adverse weather effects, as Safwat and Youssef contended. Alternatively, this reduction probably is sufficient to adjust for the negative effects of side road traffic exiting and entering evacuation routes, or for the negative effects of buses, recreational vehicles, and trailers. However, a general 20% downward adjustment probably is not adequate to account for all of these conditions, so further analyses are needed to assess the effective capacity of evacuation routes under varying weather and traffic conditions.

Finally, emergency managers in Cameron, Nueces, and Jefferson counties should note that Fall ETEs can be reduced by 3, 1, and .5 hours, respectively, because tourist occupancy is assumed to be reduced from 100% to 50%. This usually occurs in September through November, but the reduction in ETE can be applied any other time tourist occupancy is reduced substantially from full capacity. Conversely, the reduction in ETE should *not* be applied any time from September through November if tourist occupancy remains close to full capacity. The downward adjustment in Fall ETEs is not made automatically in ESTED, so users should recognize that they have an additional margin of safety during the Fall season beyond what ESTED indicates.

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APPENDIX A: VALLEY STUDY AREA

ETEs were modeled using the Evacuation Route System described by Safwat and Youssef (1997), with some exceptions noted below. Highway capacities were taken from Safwat and Youssef, but road status updates for 2002 were obtained from Regional Liaison Officers. Data from Lindell, et al. (2001) indicate that 17% of the study area population expect to travel on undesignated evacuation routes. Thus, there is some degree of conservatism in the ETEs from this source.

VSA1: South Cameron ERS
SH 4 was treated as an independent ERS because it is separated from the more northern routes in Cameron County by the Brownsville Ship Channel. Spontaneous evacuation from the inland risk areas was estimated using only the portion of the Brownsville population living in Risk Areas 4 and 5.

VSA2: North Cameron ERS
The ETEs produced using EMBLEM are much larger than those of Safwat and Youssef because the previous estimates appear to have neglected the potential for spontaneous evacuation from inland populations in Brownsville and Harlingen.

In addition, there is significant potential for traffic congestion and queues in a major hurricane because most of the large population concentration in Brownsville must travel north on US 77 before turning west onto US83 or BR 83 at Harlingen. Evacuation traffic from SH 48, SH 10, and FM 510 intersect US 77 before it reaches Harlingen, making it likely that congestion will develop here. This could create queues on SH 48, SH 10, and FM 510 that extend toward the coast into Risk Area 5.

VSA3: Willacy ERS
This county has a coastal risk area with a relatively small population, so clearance times can be expected to depend principally on TGTs (warning and preparation times). It is very unlikely that evacuation demand will challenge ERS capacity and create evacuation traffic queues. For this reason, it is possible that actual evacuation times could be significantly lower than the ETEs.

Evacuation Route System VSA1 (Cameron South)

Evacuation Route Used	*Evacuation Route Capacity*
SH 4 / US 281	800
Total Capacity of VSA1	800 vehicles/hour

Risk Areas Served: Cameron C1a, C2a, C3a, C4a, C5a

Table VSA1: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
C1a	242	335	462	517	526
C2a	104	155	225	255	264
C3a	785	1234	1842	2105	2185
C4a	1768	2884	4395	5047	5248
C5a	2558	4276	6602	7605	7914
Total vehicles	5457	8884	13526	15529	16137
ETE (hrs)	7	8	9	10	11

Evacuation Route System VSA2 (Cameron North)

Evacuation Route Used	*Evacuation Route Capacity*
FM 1792 / SH 48	800
P 100 / SH 100	800
FM 510	400
Total Capacity of VSA2	2000 vehicles/hour

Risk Areas Served: Cameron C1b, C1c, C2b, C3b, C4b, C5b

Table VSA2: Number of Evacuating Vehicles and Evacuation Time Estimates*

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
C1b	1222	1696	2338	2615	2663
C1c	6600	6600	6600	6600	6600
C2b	210	314	455	516	535
C3b	1593	2505	3740	4272	4436
C4b	5304	8651	13184	15140	15741
C5b	19242	32167	49667	57218	59542
Total vehicles	34171	51933	75984	86361	89517
ETE (hrs)	15	21	28	32	33

* Fall ETEs for VSA2 can be reduced by 3 hours because tourist occupancy is assumed to be reduced from 100% to 50%.

Evacuation Route System VSA3 (Willacy)

Evacuation Route Used	*Evacuation Route Capacity*
SH 186 *	800
FM 490 **	700
FM 506 **	700
Total Capacity of VSA3**	2200 vehicles/hour

* SH 186 is the only route available for W1, W2, W3, and W4
** Total capacity is available for W5

Risk Areas Served: Willacy W1, W2, W3, W4, W5

Table VSA3: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
W1	42	58	80	89	91
W2	13	19	27	31	32
W3	144	226	337	385	400
W4	484	789	1202	1380	1435
W5	1017	1700	2624	3023	3146
Total vehicles	1700	2792	4270	4908	5104
ETE (hrs)	7	7	7	8	8

APPENDIX B: COASTAL BEND STUDY AREA

ETEs were modeled using the Evacuation Route System described by Safwat and Youssef (1997), with some exceptions noted below. Highway capacities were taken from Safwat and Youssef, but road status updates for 2002 were obtained from Regional Liaison Officers. Highway capacities were taken from Safwat and Youssef, but road status updates for 2002 were obtained from Regional Liaison Officers. Data from Lindell, et al. (2001) indicate that 17% of the study area population expect to travel on undesignated evacuation routes. Thus, there is some degree of conservatism in the ETEs from this source.

CSA1: Kenedy/Kleberg ERS

These counties have some coastal risk areas with extremely small populations. As noted above, this could lead to significant variation in evacuation times from one evacuation to another and significant deviations of evacuation times from ETEs.

CSA2: Nueces ERS

Safwat and Youssef (1997) listed IH 37 to FM 624 as an evacuation route that is separate from IH 37, but this is incorrect because IH 37 is common to both routes. Any traffic on FM 624 must have exited from IH 37 and therefore FM 624 cannot provide additional capacity for evacuating vehicles entering the evacuation route upstream from this point. There are no entry points for evacuating vehicles that are downstream of the point at which FM 624 exits IH 37, so any vehicles diverted to this route do not increase the volume of traffic exiting the risk area.

FM 70 intersects FM 665 approximately 10 inland from the boundary of Risk Area 5 and FM 665 intersects SH 44 10 approximately 10 miles beyond that. This will result in a loss of 600 vph in traffic capacity and, thus, the formation of queues. The queue can be expected to be 6000 vehicles (approximately five miles long) at ten hours and 12,000 vehicles (approximately ten miles long) at twenty hours. At this point, the tail of the queue would be inside Risk Area 5.

CSA3: San Patricio ERS

Safwat and Youssef (1997) listed US 181 and SH 188 as separate evacuation routes, but their convergence at Sinton could produce a queue as the two routes attempt to merge onto US 181.

CSA4: Refugio/Aransas ERS

These counties have some coastal risk areas with extremely small populations. As noted above, this could lead to significant variation in evacuation times from one evacuation to another and significant deviations of evacuation times from ETEs.

Evacuation Route System CSA1 (Kenedy/Kleberg)

Evacuation Route Used	*Evacuation Route Capacity*
US 77 / SH 141	800
US 77/ SH 285	800
Total Capacity of CSA1	1600 vehicles/hour

Risk Areas Served: Kenedy: Ke1, Ke2, Ke3, Ke4, Ke5
Kleberg: Kl1, Kl2, Kl3, Kl4, Kl5

Table CSA1: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
Ke1	5	6	9	10	10
Ke2	1	2	2	2	2
Ke3	18	28	41	47	49
Ke4	5	7	11	12	13
Ke5	4	6	9	11	11
Kl1	103	142	196	219	223
Kl2	18	26	38	43	44
Kl3	287	451	673	769	799
Kl4	51	83	126	145	151
Kl5	3230	5399	8336	9604	9994
Total vehicles	3722	6150	9441	10862	11296
ETE (hrs)	7	7	8	9	9

Evacuation Route System CSA2 (Nueces)

Evacuation Route Used	*Evacuation Route Capacity*
SH 358 / SH 44	1200
IH 37 / FM 624	500
FM 70	300
FM 43 / FM 665	300
IH 37	2800
Total Capacity of CSA2	5100 vehicles/hour

Risk Areas Served: Nueces N1a, N1b, N2a, N2b, N3, N4, N5

Table CSA2: Number of Evacuating Vehicles and Evacuation Time Estimates*

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
N1a	4103	5694	7847	8777	8938
N1b	1485	2061	2841	3177	3235
N2	2818	4216	6107	6924	7175
N3	31888	50139	74849	85513	88794
N4	2810	4583	6984	8021	8339
N5	3227	5394	8328	9595	9984
Total vehicles	46331	72087	106956	122007	126465
ETE (hrs)	14	20	28	31	32

* Fall ETEs for CSA2 can be reduced by 1 hour because tourist occupancy is assumed to be reduced from 100% to 50%.

Evacuation Route System CSA3 (Refugio/Aransas)

Evacuation Route Used	*Evacuation Route Capacity*
FM 1360	600
FM 136	600
FM 774	600
US 35/ US 239	800
Total Capacity of CSA4	2600 vehicles/hour

Risk Areas Served: Refugio R1, R2, R3, R4, R5
Aransas A1, A2, A3

Table CSA4: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
R1	43	60	82	92	94
R2	16	24	35	40	41
R3	185	291	434	496	515
R4	85	138	211	242	251
R5	86	144	222	256	266
A1	441	612	844	944	961
A2	3060	4577	6630	7516	7789
A3	1999	3143	4692	5360	5566
Total vehicles	5829	8845	12928	14690	15217
ETE (hrs)	8	8	8	8	8

Evacuation Route System CSA4 (San Patricio)

Evacuation Route Used	*Evacuation Route Capacity*
SH 361 & 35/ US 181	800
SH 188	800
Total Capacity of CSA3	1600 vehicles/hour

Risk Areas Served: San Patricio S1, S2, S3, S4, S5

Table CSA3: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
S1	1805	2505	3453	3862	3933
S2	759	1135	1644	1864	1932
S3	4797	7542	11258	12862	13355
S4	979	1596	2433	2793	2904
S5	1061	1774	2739	3155	3283
Total vehicles	9401	14552	21527	24536	25407
ETE (hrs)	8	11	15	17	18

APPENDIX C: MATAGORDA STUDY AREA

ETEs were modeled using the Evacuation Route System described by Safwat and Youssef (1997), with some exceptions noted below. Highway capacities were taken from Safwat and Youssef, but road status updates for 2002 were obtained from Regional Liaison Officers. Data from Lindell, et al. (2001) indicate that 20% of the study area population expect to travel on undesignated evacuation routes. Thus, there is some degree of conservatism in the ETEs from this source.

MSA1: Calhoun/Victoria ERS
This county has a coastal risk area with a relatively small population, so clearance times can be expected to depend principally on TGTs (warning and preparation times). It is very unlikely that evacuation demand will challenge ERS capacity and create evacuation traffic queues. For this reason, it is possible that actual evacuation times could be significantly lower than the ETEs.

MSA2: Calhoun/Jackson ERS
This county has a coastal risk area with a relatively small population, so clearance times can be expected to depend principally on TGTs (warning and preparation times). It is very unlikely that evacuation demand will challenge ERS capacity and create evacuation traffic queues. For this reason, it is possible that actual evacuation times could be significantly lower than the ETEs.

MSA3: Matagorda West ERS
This county has a coastal risk area with a relatively small population, so clearance times can be expected to depend principally on TGTs (warning and preparation times). It is very unlikely that evacuation demand will challenge ERS capacity and create evacuation traffic queues. For this reason, it is possible that actual evacuation times could be significantly lower than the ETEs.

MSA4: Matagorda East ERS
This county has a coastal risk area with a relatively small population, so clearance times can be expected to depend principally on TGTs (warning and preparation times). It is very unlikely that evacuation demand will challenge ERS capacity and create evacuation traffic queues. For this reason, it is possible that actual evacuation times could be significantly lower than the ETEs.

MSA5: Victoria ERS
This county has a coastal risk area with a relatively small population, so clearance times can be expected to depend principally on TGTs (warning and preparation times). It is very unlikely that evacuation demand will challenge ERS capacity and create evacuation traffic queues. For this reason, it is possible that actual evacuation times could be significantly lower than the ETEs.

Evacuation Route System MSA1 (Calhoun/Victoria)

Evacuation Route Used	*Evacuation Route Capacity*
FM 1289 / US 87	800
SH 185	500
FM 1686 / FM 444	500
Total Capacity of MSA1	1800 vehicles/hour

Risk Areas Served: Calhoun Ca1a, Ca1b, Ca2a, Ca2b, Ca3a, Ca4
Victoria V1, V2b, V3b, V4b, V5b

Table MSA1: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
Ca1a	443	615	847	948	965
Ca1b	1368	1899	2617	2927	2980
Ca2a	252	376	544	617	640
Ca2b	1014	1516	2196	2490	2580
Ca3a	420	660	984	1125	1168
Ca4	256	417	635	729	758
V1	123	170	234	262	266
V2b	0	0	0	0	0
V3b	1030	1619	2417	2761	2867
V4b	42	68	103	119	123
V5b	103	172	265	305	317
Total vehicles	5051	7512	10842	12283	12664
ETE (hrs)	8	8	9	10	10

Evacuation Route System MSA2 (Calhoun/Jackson)

Evacuation Route Used	*Evacuation Route Capacity*
FM 1593	500
SH 172	800
FM 234 / FM 1822 / FM 3131	400
FM 1862 / FM 616 / FM 453	500
Total Capacity of MSA2	2200 vehicles/hour

Risk Areas Served: Calhoun Ca1c, Ca2c, Ca3b
Jackson J1, J2, J3, J4, J5

Table MSA2: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
Ca1c	129	179	247	276	281
Ca2c	178	265	384	435	451
Ca3b	15	23	34	38	40
J1	161	223	307	343	349
J2	147	220	319	361	375
J3	239	375	560	639	664
J4	401	654	997	1145	1190
J5	140	234	361	415	432
Total vehicles	1410	2173	3209	3652	3782
ETE (hrs)	7	8	8	8	8

Evacuation Route System MSA3 (Matagorda West)

Evacuation Route Used	*Evacuation Route Capacity*
SH 35 / SH 71 / FM 1090	500
FM 1095 / SH 35	500
FM 458	100
Total Capacity of MSA3	1100 vehicles/hour

Risk Areas Served: Matagorda M1a, M2a, M3a, M4a, M5a

Table MSA3: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
M1a	1656	2298	3167	3542	3607
M2a	502	750	1087	1232	1277
M3a	335	526	786	898	932
M4a	425	693	1056	1213	1261
M5a	190	317	489	563	586
Total vehicles	3108	4584	6585	7448	7663
ETE (hrs)	7	8	8	9	9

Evacuation Route System MSA4 (Matagorda East)

Evacuation Route Used	*Evacuation Route Capacity*
FM 2031 / FM 521 / SH 60	500
FM 457	500
FM 521 / FM 2540	100
Total Capacity of MSA4	1100 vehicles/hour

Risk Areas Served: Matagorda M1b, M2b, M3b, M4b, M5b

Table MSA4: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
M1b	322	447	616	689	701
M2b	713	1066	1544	1750	1814
M3b	322	506	755	862	895
M4b	425	693	1056	1213	1261
M5b	190	317	489	563	586
Total vehicles	1972	3029	4460	5077	5257
ETE (hrs)	7	8	8	8	8

Evacuation Route System MSA5 (Victoria)

Evacuation Route Used	*Evacuation Route Capacity*
FM 445	500
Total Capacity of MSA5	500 vehicles/hour

Risk Areas Served: Victoria V2a, V3a, V4a, V5a

Table MSA5: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
V2a	n/a	924	1339	1517	1572
V3a	n/a	85	126	144	150
V4a	n/a	68	103	119	123
V5a	n/a	172	265	305	317
Total vehicles	n/a	1249	1833	2085	2162
ETE (hrs)	n/a	7	7	7	7

n/a: An ETE is not applicable because there is no population at risk for a Category One hurricane.

APPENDIX D: HOUSTON/GALVESTON STUDY AREA

ETEs were modeled using the Evacuation Route System described by Safwat and Youssef (1997), with some exceptions noted below. Highway capacities were taken from Safwat and Youssef, but road status updates for 2002 were obtained from Regional Liaison Officers. Data from Lindell, et al. (2001) indicate that about 10% of the study area population expect to travel on undesignated evacuation routes. Thus, there is some degree of conservatism in the ETEs (i.e., overestimates) from this source.

GSA1: Brazoria ERS
This county has a moderately large population with a satisfactory ERS capacity, but there are potential problems associated with the convergence of SH 288 and BR 288 just outside Risk Area 5 and the convergence of FM 521 just beyond the intersection of these two routes. Moreover, SH 35 intersects SH 6 at Alvin (just outside Risk Area 5) and the latter is expected to carry evacuation traffic from GSA2. This could cause queues to form in a Category Five hurricane that extend back into the study area.

GSA2: Galveston West/Harris South ERS
As reported by Urbanik (1979), it is likely that the limiting factor for the evacuation of Galveston Island will be the ability of the surface streets to supply a steady flow of traffic to IH 45, not the capacity of IH 45 itself. Moreover, as noted above, SH 35 intersects SH 6 at Alvin (just outside Risk Area 5) and the latter is expected to carry evacuation traffic from GSA1. This could cause queues to form in a Category Five hurricane that extend back into the study area. In addition, evacuation from risk areas and inland areas outside the South Harris County study area could add unanticipated demand to IH 45 that could add to queues on this evacuation route.

GSA3: Harris Central ERS
This ERS has a very dense network of arterials and highways that could supply a significant amount of traffic capacity to complement the designated evacuation routes. However, risk area residents and evacuees from areas inland from the study area are likely to attempt to use the PERs unless they are directed to take other routes. Detailed traffic management plans will be essential to ensure that major queues do not form in this ERS in the event of a Category Four or Five hurricane.

GSA4: Harris East ERS
This ERS also has a very dense network of arterials and highways that could supply a significant amount of traffic capacity to complement the designated evacuation routes. Unlike GSA3, evacuation by risk area residents and evacuees outside the study area (i.e., north of IH 10) is unlikely to conflict with evacuations from other risk areas. Detailed traffic management plans should be established, but major queues are not very likely to form in this ERS in the event of a major hurricane.

Evacuation Route System GSA1 (Brazoria)

Evacuation Route Used	*Evacuation Route Capacity*
SH 36	650
SH 288	1850
BR 288	650
FM 521	500
SH 35	650
Total Capacity of GSA1	4300 vehicles/hour

Risk Areas Served: Brazoria B1, B2, B3, B4, B5

Table GSA1: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
B1	3748	5202	7169	8019	8165
B2	7143	10685	15480	17550	18186
B3	3538	5562	8303	9486	9850
B4	4955	8082	12315	14142	14704
B5	1548	2588	3995	4603	4790
Total vehicles	20932	32119	47262	53800	55695
ETE (hrs)	7	9	13	15	15

Evacuation Route System GSA2 (Galveston West/Harris South)

Evacuation Route Used	*Evacuation Route Capacity*
SH 6	1000
IH 45	4800
Total Capacity of GSA2	5800 vehicles/hour

Risk Areas Served: Galveston G1a, G2, G3, G4, G5
Harris H1a, H2a, H3a, H4a, H5a

Table GSA2: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
G1a	16577	23005	31709	35465	36115
G2	8966	13412	19431	22028	22827
G3	11986	18846	28134	32142	33375
G4	3567	5818	8866	10181	10586
G5	3734	6241	9637	11102	11553
H1a	11070	15363	21175	23683	24117
H2a	1180	1765	2557	2899	3004
H3a	3741	5882	8780	10031	10416
H4a	4030	6574	10018	11505	11962
H5a	3732	6238	9632	11096	11547
Total vehicles	68583	103144	149939	170132	175502
ETE (hrs)	14	20	28	32	33

Evacuation Route System GSA3 (Harris Central)

Evacuation Route Used	*Evacuation Route Capacity*
US 146 / SH 225	3200
Belt Road 8	1400
Total Capacity of GSA3	4600 vehicles/hour

Risk Areas Served: Harris H1b, H2b, H3b, H4b, H5b

Table GSA3: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
H1b	2435	3379	4657	5209	5304
H2b	1282	1917	2778	3149	3263
H3b	5011	7878	11761	13437	13952
H4b	2288	3731	5686	6529	6789
H5b	2893	4835	7465	8600	8950
Total vehicles	13909	21740	32347	36924	38258
ETE (hrs)	7	7	9	10	10

Evacuation Route System GSA4 (Harris East)

Evacuation Route Used	*Evacuation Route Capacity*
IH 10 / Belt Road 8	2500
IH 10 / Belt Road 610	800
SH 146	800
US 90	800
Total Capacity of GSA4	4900 vehicles/hour

Risk Areas Served: Harris H1c, H2c, H3c, H4c, H5c

Table GSA4: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
H1c	4914	6820	9400	10513	10706
H2c	3269	4890	7084	8031	8322
H3c	7755	12193	18202	20795	21592
H4c	6776	11053	16843	19342	20111
H5c	9160	15312	23642	27237	28343
Total vehicles	31874	50268	75171	85918	89074
ETE (hrs)	8	12	17	19	20

APPENDIX E: LAKE SABINE STUDY AREA

ETEs were modeled using the Evacuation Route System described in the SSA Evacuation Plan adopted 1 June 1999. This plan directs all traffic to the north, but approximately 30% of the survey respondents indicated that they expected to travel to destinations in Central, South, or West Texas. Consequently, a significant number of evacuees should be expected to attempt to travel westbound on IH 10, US 90, and SH 105.

Highway capacities were taken from Safwat and Youssef, but road status updates for 2002 were obtained from Regional Liaison Officers. Data from Lindell, et al. (2001) indicate that about 35% of the study area population expect to travel on undesignated evacuation routes. Thus, there is some degree of conservatism in the ETEs (i.e., overestimates) from this source.

SSA1: Chambers West ERS
This county has multiple evacuation routes, so queues are not likely to develop. However, these evacuation routes converge in Liberty County and queues might develop there instead.

SSA2: Chambers East/Galveston East ERS
This ERS also includes evacuees from the Bolivar Peninsula who must travel parallel to the coast before turning inland. This significantly increases the travel time on the PER.

SSA3: Hardin ERS
The risk areas are small and lightly populated so, as noted above, ETEs could overestimate actual evacuation times. However, Hardin County is a transit route for evacuees from Jefferson County travelling north, so queues could develop in Risk Areas 4 and 5 near Lumberton.

SSA4: Jasper ERS
The risk areas are small and lightly populated so, as noted above, ETEs are likely to overestimate actual evacuation times.

SSA5: Jefferson/Orange West ERS
Port Arthur and points south are expected to evacuate through Beaumont, which itself has a population that is sufficient to challenge the capacity of the principal evacuation route (US69/96/281). Local planners should consider balancing the demand by assigning traffic from southeast Jefferson County via SH 87 into Orange County.

SSA6: Liberty ERS
The risk areas are small and lightly populated so, as noted above, ETEs are likely to overestimate actual evacuation times.

SSA7: Newton ERS
The risk areas are small and lightly populated so, as noted above, ETEs are likely to overestimate actual evacuation times.

SSA8: Orange East ERS
This county has multiple evacuation routes, so queues are not likely to develop.

Evacuation Route System SSA1 (Chambers West)

Evacuation Route Used	*Evacuation Route Capacity*
SH 61	800
IH 10 / FM 563	600
SH 146	200
Total Capacity of SSA1	1600 vehicles/hour

Risk Areas Served: Chambers Ch1a, Ch2a, Ch3, Ch4, Ch5

Table SSA1: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
Ch1a	845	1173	1617	1808	1841
Ch2a	260	389	563	638	661
Ch3	546	859	1282	1465	1521
Ch4	422	688	1049	1204	1252
Ch5	250	418	645	743	773
Total vehicles	2323	3527	5156	5858	6048
ETE (hrs)	7	7	7	8	8

Evacuation Route System SSA2 (Chambers East/Galveston East)

Evacuation Route Used	*Evacuation Route Capacity*
SH 124 / FM 1406	800
Total Capacity of SSA2	800 vehicles/hour

Risk Areas Served: Chambers Ch1b, Ch2b
Galveston G1b

Table SSA2: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
Ch1b	412	572	789	882	898
Ch2b	476	712	1031	1169	1212
G1b	4881	6774	9337	10443	10634
Total vehicles	5769	8058	11157	12494	12744
ETE (hrs)	10	13	17	19	19

Evacuation Route System SSA3 (Hardin)

Evacuation Route Used	*Evacuation Route Capacity*
US 96	1600
Total Capacity of SSA3	1600 vehicles/hour

Risk Areas Served: Hardin Ha1, Ha2, Ha3, Ha4, Ha5

Table SSA3: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
Ha1	82	114	157	176	179
Ha2	48	72	104	118	123
Ha3	196	308	460	525	545
Ha4	389	635	967	1111	1155
Ha5	262	437	675	778	809
Total vehicles	977	1566	2363	2708	2811
ETE (hrs)	7	7	7	7	7

Evacuation Route System SSA4 (Jasper)

Evacuation Route Used	*Evacuation Route Capacity*
US 96	1600
Total Capacity of SSA4	1600 vehicles/hour

Risk Areas Served: Jasper Ja1, Ja2, Ja3, Ja4, Ja5

Table SSA4: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
Ja1	1	2	2	3	3
Ja2	1	2	2	3	3
Ja3	14	22	33	38	39
Ja4	10	688	1049	1204	1252
Ja5	11	17	27	31	32
Total vehicles	37	731	1113	1279	1329
ETE (hrs)	7	7	7	7	7

Evacuation Route System SSA5 (Jefferson/Orange West)

Evacuation Route Used	*Evacuation Route Capacity*
SH 87 / US 69	1600
IH 10 / FM 105	1600
Total Capacity of SSA5	3200 vehicles/hour

Risk Areas Served: Jefferson Je1, Je2, Je3, Je4, Je5
Orange O1a, O2a, O3a, O4a, O5a

Table SSA5: Number of Evacuating Vehicles and Evacuation Time Estimates*

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
Je1	1939	2691	3709	4149	4225
Je2	2069	3094	4483	5082	5266
Je3	17894	28135	42002	47985	49826
Je4	6438	10502	16003	18378	19108
Je5	3942	6590	10175	11722	12198
O1a	728	1010	1391	1556	1585
O2a	790	1182	1712	1941	2011
O3a	819	1288	1923	2197	2281
O4a	492	802	1222	1403	1459
O5a	426	712	1099	1266	1317
Total vehicles	35537	56006	83719	95679	99276
ETE (hrs)	14	20	29	33	34

* Fall ETEs for SSA5 can be reduced by .5 hour because tourist occupancy is assumed to be reduced from 100% to 50%.

Evacuation Route System SSA6 (Liberty)

Evacuation Route Used	*Evacuation Route Capacity*
US 90 / SH 146	800
US 90 / SH321	800
Total Capacity of SSA6	1600 vehicles/hour

Risk Areas Served: Liberty L2, L3, L4, L5

Table SSA6: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
L2	n/a	93	135	153	159
L3	n/a	1632	2435	2782	2889
L4	n/a	833	1269	1458	1515
L5	n/a	440	679	782	814
Total vehicles	n/a	2998	4518	5175	5377
ETE (hrs)	n/a	7	7	7	7

n/a: An ETE is not applicable because there is no population at risk for a Category One hurricane.

Evacuation Route System SSA7 (Newton)

Evacuation Route Used	*Evacuation Route Capacity*
US 87	800
Total Capacity of SSA7	800 vehicles/hour

Risk Areas Served: Newton N1, N2, N3, N4, N5

Table SSA7: Number of Evacuating Vehicles and Evacuation Time Estimates

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
N1	n/a	n/a	8	9	9
N2	n/a	n/a	1	1	1
N3	n/a	n/a	0	0	0
N4	n/a	n/a	1107	1271	1321
N5	n/a	n/a	2299	2649	2756
Total vehicles	n/a	n/a	3415	3930	4087
ETE (hrs)	n/a	n/a	7	9	9

n/a: ETEs are not applicable because there is no population at risk for hurricanes in Categories One–Three.

Evacuation Route System SSA8 (Orange East)

Evacuation Route Used	*Evacuation Route Capacity*
US 87	800/1600[a]
US 62	1600/800
Total Capacity of SSA8	2400 vehicles/hour

[a] US 62 has four lane capacity south of IH 10 and two lane capacity north of it, whereas US 87 has two lane capacity south of IH 10 and four lane capacity north of it. Consequently, it is assumed that half of the traffic on US 62 will travel to US 87 via IH 10.

Risk Areas Served: Orange O1b, O2b, O3b, O4b, O5b

Table SSA8: Number of Evacuating Vehicles and Evacuation Time Estimates*

	Storm Category				
Risk Area	Category One	Category Two	Category Three	Category Four	Category Five
O1b	2182	3028	4173	4668	4753
O2b	1358	2031	2942	3335	3456
O3b	3819	6005	8964	10241	10634
O4b	989	1613	2458	2823	2935
O5b	519	867	1339	1543	1605
Total vehicles	8867	13544	19876	22610	23383
ETE (hrs)	7	7	10	11	12

* Fall ETEs for SSA8 can be reduced by .5 hour because tourist occupancy is assumed to be reduced from 100% to 50%.